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Some Phycomycetous Diseases of Cultivated Plants in the Philippines

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While it is generally known that some of the principal drawbacks in Philippine agriculture are plant diseases and that the death of the once flourishing coffee industry and the great peril of coconut growing were due to these causes, it is strange to find a lack of serious and definite attention being given to plant diseases in the Philippines. The government has no competent personnel in its service to attend to even the most urgently necessary investigations. It is only very recently that provisions have been made which will permit the College of Agriculture to employ one Plant Pathologist.

This institution, realizing the tremendous importance of the situation, has continually been calling the attention of the authorities to the matter and has been actively carrying on investigations of certain plant diseases. The present paper is the joint work of two graduate members of the class in Botany IV, in which these subjects are considered.

SERIOUSNESS OF THE PHYTOPHTHORA DISEASES

It appears that some of the most destructive diseases of plants belong to the genus *Phytophthora*. One of these is the so-called late blight or downy mildew of the potato, *Phytophthora infestans* (Mont.) de Bary, which is supposed to have originated in South America, and to have been brought to the United States about 1840. It is met with in all potato-growing countries of the world, and causes more damage to the potato than all other injuries combined (5).

It was estimated that in New York State alone the blight had caused a loss of $10,000,000 in one year, while the annual loss in the United States is placed at $36,000,000. The loss reported in one year from Ohio was $2,000,000; from Wisconsin, $5,000,000.

The tomato blight, which is said to arise from the same cause as the potato blight, causes complete destruction of the crops in some sections of the United States and the consequent loss of many thousands of dollars. It has been reported in Massachusetts, Colorado and California. According to Tubeuf and Smith (7), it attacks the leaves, shoots, and tubers of other *Solanaceae*, such as *Solanum caripense* and *Solanum hybridum* (8).

The cacao-pod disease (2), which is caused by *Phytophthora omnivora* de Bary, has been present for a long time in the West Indies, and lately has become much more general and destructive in Trinidad. It is said that the same disease has been proved to be present on cacao pods in Ceylon, and that it is probably present to some extent wherever cacao is cultivated.

The lima-bean mildew, *P. Phaseoli* Thaxter (2), is the cause of serious injury to the Lima bean (*Phaseolus lunatus*) in the United States. It attacks the pods especially, while less frequently it also develops on the leaves and petioles.

The black rot of betel-nut palm (*Areca Catechu*) is also reported as caused by a species of *Phytophthora* and as prevalent in the Maluad districts of Mysore.

Material Studied

The present study deals with two Phytophthora diseases, cacao-pod disease, and Colocasia blight, and with the damping-off fungus.

The Oriental Cacao-pod Disease.—*Phytophthora Faberi* Maubl.

Report of the presence of this disease in the Philippines was published last November (10). Massee (2) ascribes the disease to *Phytophthora omnivora* and says that it occurs in the West Indies, Ceylon, Sao Thomé, Samoa, Java, the Cameroons, and Tropical America (11). According to Massee, it attacks, besides cacao pods, beech seedlings, and seedlings of *Cactus*, *Acer*, *Fraxinus*, *Robinia*, *Fagopyrum*, *Sempervivum*, *Clarkia*, and conifers.

It is interesting to note that Saccardo does not mention *P. omnivora* as a parasite on cacao, but mentions *P. Theobromae*, which, as will be pointed out later in this paper, we have reason to suspect is a different species from *P. omnivora*.

For purposes of identification of the species we have studied, we quote the following (3, 9):

"Phytophthora Faberi Maubl., in L'Agricult. prat. des Pays Chauds, n. 79 (1909) p. 315, Phytophthora Theobromae Lesl. C. Coleman, Ann. Mycol. VIII (1910) pag. 621, c. ic.—Maculis irregulariter brunneis; ramoso, primum continuo demum septato; sporangiophoris 150-200 micron longis; haustoriis non visis; sporangiis plerumque ovoideis sed magnitudine variabilibus, 42-80×25-30 micron; oogoniis intramatricalibus; antheridiis nullis v. raris; oosporis plerumque parthenogenetice ortis, cavitatem oogonialem late occupantibus, sphaeroides, elongatis v. irregularibus 22-45 micron diam.

Hab. parasitice in fructibus Theobromae Cacao, Heveae brasilensis, Artocarpi incisae in India or.

Phytophthora Cactorum (C. et L.) Schroet. Krypt. Fl. Schles. p. 236, Peronospora Cactorum Cohn et. Lebert Beitrage zur Biol. d. Pflanzen I, p. 56, Peronospora Fagi Hartig, P. Sempervivi Schenk, Phytophthora omnivora De Bary. —Hyphis mycelicis gracilibus nonnumquam torulosis, ramosis; ramis angulo recto patentibus, haustoriis destitutis; hyphis conidiophoris tenuibus unilateraliter parce ramosis, sub apicibus ramorum conidiferorum non raro vesiculoso inflatis; conidiis, in hyphis, paucis hyalinis, ellipsoideis vel ovatis, 50-60-90 × 35-40 micron, apice papilla prominente munitis, zoosporis usque ad 50 micron

gignentibus; oogoniis conglomeratis membrana tenui marcesente munitis singulis oosporam, singulam exacte globosam, 24-30 micron diam., opisporio valido luteo-fusco, pellucido, levi praeditam foventibus.

Hab. in meatibus intercellularibus parenchymatis variorum Cactorum in Vratislavia aliisque in plantis; ex gr. Sempervivo, Cleome, Clarkia, Alonsoa, Schizantho etc., in Germania."

From the above descriptions from Saccardo, it seems that *Phytophthora Theobromae* is a different species from *Phytophthora omnivora.*

The specimens studied in this work were obtained from affected pods of a cacao tree growing in the barrio of San Antonio, Los Baños, Laguna province. Pictures of some of these diseased pods are shown in Plate I.

It is found that the parasite attacks pods of all ages and those pods which are caught immature are prevented by the fungus from reaching maturity. The younger pods are soon killed.

The first symptom of the disease is a blackening of the skin of the pod within the furrows, which is followed by the appearance of white mould, most of the latter being found in the furrows of the pod. In the case of *Phytophthora omnivora*, this white mould represents the conidial fruit of the fungus and is dispersable by wind and rain. The mycelium of *Phytophthora omnivora* "permeates the entire substance of the shell, and often also attacks the seeds. Numerous resting-spores are produced in the diseased tissues, and are liberated when the shell decays. These resting spores often germinate and produce the conidial form of the fruit, which commences the disease afresh another season" (2).

The hyphae of our cacao disease are very slender and irregularly branched. The sporangia are lemon-shaped and are 33 to 53 microns long and 21 to 30 microns broad. These dimensions of the sporangia seem to indicate that the species under consideration is *Phytophthora Faberi* Maubl. (*Phytophthora Theobromae* Sesl.).

After each of the recent baguios, papaya fruits of different ages which were blown down by the wind were found to be covered with patches of white mold. Plate II shows one such infected fruit.

Upon preliminary examination it was found that the fungus was a species of *Phytophthora*, and for a time it was thought that it was a different species from that attacking the pods of cacao. As the work progressed, however, suspicions began to arise that these supposedly different species were identical, and steps were taken immediately to determine this. Three fresh and healthy papaya fruits were wounded with a sterilized knife and inoculated with *Phytophthora* from cacao, and placed under a bell jar. This was done twice and in both cases a luxuriant growth of white fungus promptly resulted. Microscopic examinations show that the *Phytophthora* species on cacao is the same as that on papaya.

It is interesting to note that, in the field, the rapid infection of papaya fruits, following the baguios, took place at points remote from any cacao trees, showing that spores of this fungus must be commonly distributed everywhere. The important fact is that the fungus develops on other plants than cacao.

In both the cacao and papaya diseases, *Phytophthora Faberi* is the primary agent, but it is quickly followed by other fungi, commonly by *Lasiodiplodia.*

To combat the disease, Ghofulpo, in his study of cacao and its local diseases (10), concluded:

1. To prevent or check the ravages of the fungus and insect enemies of the cacao, spraying with Bordeaux mixture has proved every satisfactory. It should be done thoroughly and at the proper time, with an efficient apparatus.

2. The combating of the enemies of cacao is a matter of great enough economic importance to be worthy of the most serious attention of all owners of large or small plantations.

3. Dead or dying pods, leaves, or branches should be removed from the trees with a sharp knife and burnt.

Proper fertilization and pruning have been recommended.

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Phytophthora Colocasiae—Rac.

A common disease of the "gabi," *Colocasia Antiquorum*, is called Colocasia blight and is caused by *Phytophthora colocasiae* Rac. It has been observed from a gabi field at Anos, Los Baños; it attacks the leaves of *C. Antiquorum*. It is interesting to note that several yautia plants (*Xanthosoma*) growing among infected gabis did not show any sign of infection from the same disease.

The disease has already been reported from Java, India, and Formosa (12).

It is said that the disease first shows itself ordinarily on the leaf in dark roundish specks which widen rather rapidly by centrifugal growth. These patches may be circular, oval, elongated, or may possess any other shape. In their spread, the main leaf-vein serves as a temporary check. At the beginning, the surface of the affected part produces a clean yellow liquid. Later, the attacked part turns yellow, dries up, and at times becomes full of small holes. The edges exhibit different shades of brown, green and yellow, and there the fungus is found in the sporangial stage. When the attack on the leaves is very severe, all the leaves may be lost and the plant killed.

The fungus is also found on the petioles, outside and rarely on the inside, the infected part being usually elongated in the direction of the axis of the stalk. The disease is sometimes serious enough to cause the breaking of the petioles.

From the petioles, the disease may reach the corms, especially such as are not covered with the soil and, therefore, liable to come in contact with the infected leaves that fall to the ground.

The corm rot is not often observed in the field. It is more usually found subsequently when the corms are in storage.

Infection of the inflorescence is reported to be rare.

Regarding the effect of the disease on the yield of the plants, it is either that the corms are prevented from forming, or they are formed but abnormally, while if the leaves are only slightly affected, no effect is manifest in the yield.

It has been stated that the disease spreads rapidly during wet weather.

Microscopic Study

The material studied in this work came partly from infected leaves direct, or from cultures, in which the medium was sterilized fig-liquor.

The mycelium is found in the leaf, petiole, inflorescences, and corms which are infected with the disease. According to Butler and Kulkarni, the hyphae vary from 0.004 mm., usually 0.005 or 0.006 mm. up to as much as 0.012 mm. in diameter. No observation was made of the manner in which the hyphae penetrate the leaves, but it is stated that they are purely intercellular, in the leaf-mesophyll and in the petiole;

in the latter they are especially found in the intercellular spaces, while in the corm, they are found in storage cells and are intra- rather than intercellular. In the leaves and petioles, the bundles are not penetrated, but in the corm even this occurs. Results of the studies of other authors suggest that it is not so much the structure of the wall, as the nature of the substances occurring within the cells, that decides whether or not penetration will take place.

Asexual reproductive organs (12) are not found internally, but are produced externally on short stalks which arise from the epidermis at the margins of the spots on both surfaces of the leaf blade and on the petiole. The sporangia drawn from our material came from the leaf. They appeared colorless, and more or less elliptical in shape. The two sporangia measured gave 0.210 mm. and 0.185 mm. for the length and 0.07 mm. and 0.075 mm. for the breadth. Published studies (12) give 0.038 to 0.060 as the diameter and 0.114 mm. as the length. The widths obtained by the authors of the present work appear to be greater than those observed elsewhere. This may be due to the fact that the sporangia measured came from the cultures. Indeed, Butler and Kulkarni (12) state that the dimensions of the sporangia vary widely in culture. In India the length rarely exceeds 0.06 mm. Some sporangia were found to possess one vacuole each, and the above authors state that these are the mature ones. Maturity takes place in three days. Each sporangium may produce up to twenty zoospores, which, according to Butler and Kulkarni, are more or less bean-shaped, one of the longer sides being convex and the other concave or plane. According to the same authors, each has a small pulsating vacuole and also two cilia which arise near together from the concave or plane side. One of these projects in front and the other behind while swimming. After swimming for some time they come to rest, round off, lose the cilia and become surrounded with a cellulose wall. At this period they measure from 10 to 13 microns in diameter (other writers give the measurement o the swimming spores as 14 to 18 by 9 to 13 microns). Germination occurs by a germ-tube which may be protruded within half an hour after the zoospore comes to rest or within an hour after the zoospores have come out from the sporangium. The germ-tube grows and branches for a time, but in water dies without forming any definite mycelium.

Treatment of the Disease

Sawada (12) has proved the efficiency of Bordeaux mixture in checking the Colocasia blight. However, this method of treatment is so expensive that it is doubtful if it could be adopted by an ordinary gabi raiser. It is believed it could be practiced only in very severe attacks.

Other methods recommended are the removal of all spotted leaves during the early stages of the attack; the frequent examination of corms being kept for seed, and the removal of those which show signs of rotting; and the use of sound corms only for seed at the planting time.

As the humidity of the air favors the spread of the disease, it has been recommended that planting in shady localities should be avoided. Greater relief may be expected from the substitution of yautias, which seem to be immune, for gabis, among the farmers generally. It has been found, on trial, that they take to this change very kindly.

Pythium de Baryanum Hesse

This is the "damping off" disease, said to be a very common facultative parasite in garden soils in Europe and the United States (12). It was only very recently reported in India, and, more recently still, in the Philippines. It attacks seedlings of *Camelina sativa*, *Lepidium sativum*, and is the cause of the disease of beet-root, known as "Wurzelbrand." It was also found in the caruncle of the seed of *Ricinus communis*. Seedlings of turnips, rape, mustard, and other Cruciferous plants, as well as clover, mangold, etc., are also subject to the attacks of this fungus.

In the Philippines it has been known to attack seedlings of lettuce, tomato, and other vegetables, as well as tobacco. In certain cases in gardening work of the Philippine Normal School, about 20% of the seedlings of lettuce have been attacked. In the nursery of the College of Agriculture about 20 to 30% of tobacco seedlings growing in nursery flats are sometimes killed. Overcrowding, too much water, and lack of sunlight, have been found to be favorable to the development and spread of the disease.

The material used in this study came from infected seedlings of tobacco which were allowed to rot in a petri dish in a small amount of water.

The mycelium found consisted of branched hyphae, which, in general, taper regularly. They may be also regular in shape and septate. Many vacuoles have been found inside the hyphae.

The reproductive bodies produced on tobacco seedlings are chiefly zoospores. No sporangia were found. Butler states that sporangia appear to be rarely produced on plant tissues, whereas on animal tissues, such as ants, they are formed on the second day in great abundance. The following is quoted from Butler (12): The sporangia "are terminal or intercalar, the former being mostly spherical, the latter elliptical or irregular. The hypha near a sporangium is frequently emptied of its contents, the empty part being sometimes cut off from the full by a septum. Germination in undisturbed cultures generally occurs while the sporangium is still attached to the mycelium. A very prominent beak is formed, generally about equal to the diameter of the sporangium in length. A single large vacuole is present in mature sporangia but disappears shortly before zoospore-formation. The latter process is exactly similar to that of other species of the genus, the sporangial contents escaping into a thin-walled vesicle formed at the apex of the beak and maturation of the zoospore taking place within the vesicle. Five to eighteen or more zoospores may be produced by a sporangium."

According to Butler, when the zoospore is first liberated, it is longer than broad, the two longer sides being unequal in length and the shorter of the two sometimes depressed in the center, the shape being like a bean, somewhat flattened vertically, and with one end more pointed than the other. They are two-ciliated, and have never been known to divide into two one-ciliate secondary zoospores. When a zoospore germinates, a single germ-tube is produced, which grows to a considerable length, and is sometimes septate.

The oospores, as the writers of this paper found, are more or less spherical in shape, about 0.063 mm. in diameter. The diameter of the oogonium is about 0.0936 mm. a smaller oogonium and oospore gave 0.0432 mm. and 0.0198 mm. as their respective diameters. The smallest oospore found was only 0.018 mm. in diameter.

Conditions which predispose seedlings to this disease are overcrowding; growth in damp, stuffy localities; excess of water in the soil; excess of organic matter, especially decaying vegetable debris; and use of the same soil over and over again in plant houses and pots.

BIBLIOGRAPHY

1. 1913 *Memoirs of the Department of Agricultural Research Institute*, Pusa, Vol. V, No. 5; Butler and Kulkarni, *Studies in Peronosporaceae.*

2. 1910 George Massee: *Diseases of Cultivated Plants and Trees.*

3. Saccardo: *Sylloge Fungorum*, Vol. 21, p. 860.

4. Cooke: *Fungoid Pests of Cultivated Plants*, p. 212.

5. Stevens and Hall: *Diseases of Economic Plants.*

6. H. Marshall Ward: *Diseases in Plants*, pp. 115, 136, 144, 150, 151, 235, 236,

7. Tubeuff and Smith: *Diseases of Plants.*

8. *Revista Ecuatoriana*, 1891.

9. Saccardo: *Sylloge Fungorum*, Vol. 7, p. 238.

10. The Philippine Agriculturist and Forester, Vol. IV, No. 8.

11. Bancroft, K. (1910): A *Handbook of the Fungus Diseases of West Indian Plants*, pp. 13, 14, 23.

12. Butler and Kulkarni: *Studies in Peronosporaceae, Memoirs of the Department of Agriculture in India*, Vol. V, No. 5, pp. 1-263.

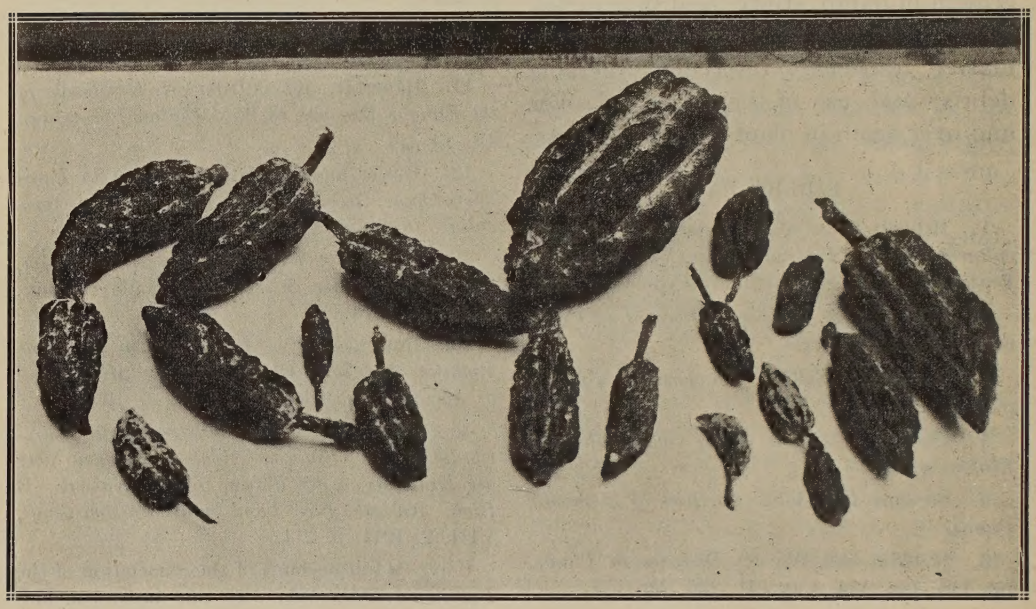
13. Hesse, R.: *Ueber Pythium de Baryanum, ein endophytischer Schmarotzer*, Halle (*Inaugr. Dissert.*), 1874.

14. Butler, E. J.: *An account of the genus Pythium and some Chytridiraceae. Mem. Dept. of Agr. in India, Bot. Ser.*, I, No. 5, 1907.

15. Peters, L.: *Ueber die Errneger des Wurzelbrandes, in Busseew. Untersuchungen uber die Krankheiten der Ruben, 5, Arb. Kaiserl.* B *Biol. Anstatt fur Land und Forstwirtshaft*, VIII, 2, 1911, p. 211.

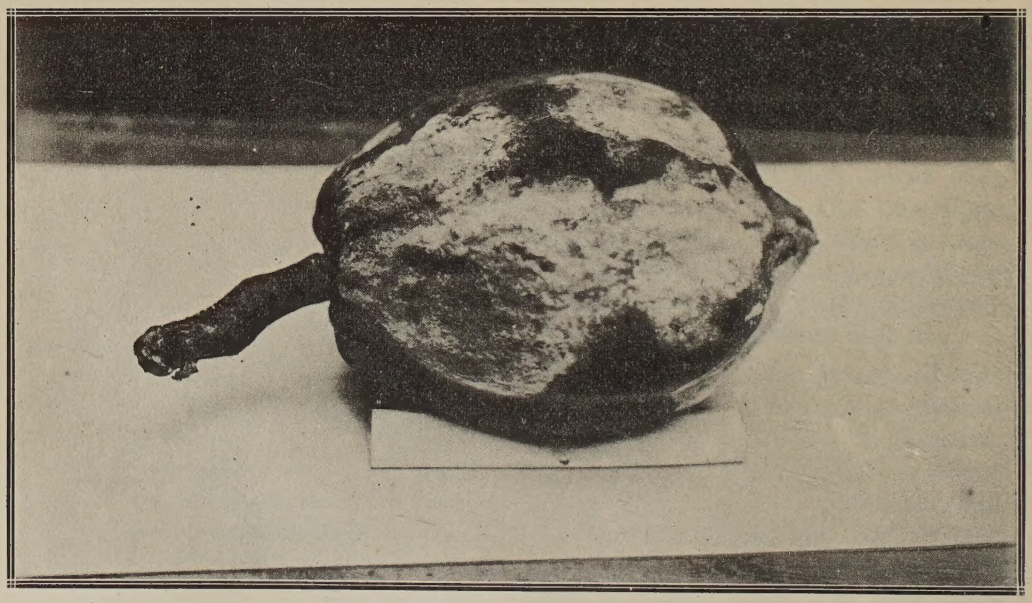
(Gives a full account of the association of the *Pythium de Baryanum* with this disease, including reference to previous work.).

PLATE I.



Phytophthora Faberi on Cacao Pods

PLATE II.



Phytophthora Faberi on Papaya Fruit

Additional Notes on Philippine Plant Diseases

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In the two years since the publication of *A Review of Some Philippine Plant Diseases*, our knowledge of this subject has advanced very materially, through our own discoveries in the field and laboratory, and through the continued work of Rehm in Munich, Sydow in Berlin, Saccardo in Padua, and Diedicke in Erfurt. These well known authorities have been giving a large part of their time to our work without expense to the Philippine Government, and with results of great value to Philippine agriculture, since it is the basic work which points the way to further investigation, and which coördinates our work with that being done in all other countries.

The past year has been signalized by two occurrences of great moment in connection with Philippine plant pathology. The first was the visit of Dr. Edson, of the U. S. Department of Agriculture, who made inspection trips through the Islands and formulated recommendations for the development of plant pathology in the Islands. He was accompanied in his journey through Northern Luzon by Mr. J. J. Mirasol. The second important occurrence was the recent election of Mr. Otto Reinking of the Colorado Agricultural College and Experiment Station to the post of plant pathologist in the College of Agriculture of the University of the Philippines. Mr Reinking expects to be on the ground by July 15th.

In the meantime field observations and practical work in connection with various diseases have continued slowly but without intermission, as the following notes will show. Up to this time our work in mycology and plant pathology has had to be a labor of love, confined to spare moments, or done in connection with desultory attempts to present Botany IV to small groups of advanced students. It has proceeded still more slowly during the past two years, due to the absence of Mr Raymundo in America, and the giving of the small amount of Mr Reyes' time which was available to the treatment of diseases and pests in the field, and to the instruction of other students in this work.

Ananas sativus—Pineapple

In our pineapple plantation, during the past year, the lower leaves of the plants were fungus-ridden, these leaves dying in rapidly extending brown areas. The fungus concerned proves to be *Asterinella Stuhlmanni* (Henn.) Theiss.

Annona muricata—Guanabano

Leaves of this fruit tree commonly die off in considerable numbers, the dying areas turning whitish and extending irregularly inward from the margin of the leaf. The fungus is a new species, *Phyllosticta Insularum* Sacc.

Areca Catechu—Betel Palm

We find that this palm is often extensively infected with the coconut leaf spot caused by *Pestalozzia Palmarum* Cooke, the effects being quite characteristic. In addition to this, the leaves often present extensive irregular whitish dead areas which bear the fungus *Phomopsis palmicola* (Wint.) Sacc. f. *Arecae* Sacc. nov. A new and very interesting leaf parasite of this palm produces large numbers of small, dark-colored raised fruiting bodies on the surface of the leaf, and has just been described by Saccardo under the name *Exosporium pulchellum*. In one tree examined by us, areas of dead bark

bore a fine new fungus, *Anthostomella Arecae* Rehm.

Arenga saccharifera—Cabo Negro

A fungus not before reported from the Philippines, *Microdiplodia passeriniana* (Thum.) Allesch. appears locally in great force on the leaves of this palm. Its appearance to the eye is very similar to that of *Exosporium pulchellum* Sacc. on *Areca*. A new leaf disease, killing large areas, these whitish areas extending in sub-concentric zones, is caused by *Phomotospora migrans* Rehm.

Barleria cristata—Culanta

This valuable ornamental shrub sometimes dies back very rapidly, becoming covered with a ragged mass of dead twigs. In one case we found these twigs inhabited by a new fungus, *Diatrypella Barleriae* Syd.

Canavalia gladiata—Red Sword Bean

The stems of trailing legumes, shortly after maturity, are attacked by various fungi and rapid decay follows. This is an item of importance in connection with those legumes which are to be plowed under as green manures after the seed crop is taken off, particularly in those having tough woody stems. We have mentioned in the *Review* two fungi which work in this way on *Dolichos uniflorus*. In the case of *Canavalia gladiata* the fungus expecially active in this work in a new species, *Physalospora guignardioides* Sacc.

Capsicum annuum—Red Pepper

Pepper pods dried and hung in strings became badly fungus-affected during protracted moist weather and this fungus proves to be *Phomopsis Capsici* (Magnaghi) Sacc., originally described from Italy.

Carissa arduina

In experimental plantings of this fruiting shrub, a large part of the leaves sometimes turn brown and drop off and these leaves we find to be covered with *Pestalozzia funerea* Desm., the same fungus which we had found before on dead areas of leaves of mango.

Citrus nobilis—Naranjita

A noteworthy addition to the list of interesting fungi to be found on dead and dying limbs of our common orange, is the new species *Zignoella nobilis* Rehm.

Cocos nucifera—Coconut

At Uube, on the slope of Mt. Banahao above Majayjay, coconuts were found affected by a disease which causes the leaves to turn yellow and become covered with small spots. On the lower surface of the leaves numerous dark-colored, raised fruiting bodies of the fungus may be encountered, and this turns out to be a species new to science, *Exosporium durum* Sacc. Superficially, this fungus bears a remarkable resemblance to *Microdiplodia passeriniana* (Thum.) Allesch. which may be found in the same locality on Arenga. It also closely resembles *Exosporium pulchellum* Sacc. on *Areca*, and *Graphiola cylindrispora* Syd.—the latter being abundant on *Livistona* on Mt. Makiling. The matured and dying lower leaves of the coconut often have their petioles attacked by a new fungus, *Chaetosphaeria eximia* Sacc.

Colocasia Antiquorum—Gabi

This plant—a standard Philippine vegetable—suffers very severely from fungus attacks. Frequently all the leaves on the plant are destroyed or in part show spots or extensive browned and ragged areas. Messrs. Mendiola and Espino (supra) have shown this to be due largely to *Phytophthora Colocasiae* Rac., a serious disease reported from surrounding countries. Butler

records it as a serious disease in India. It was originally described from Java.

Coffea excelsa

Our plantings of this coffee have been very successful, and on the whole it appears to be remarkably free from fungus attack of any kind. Occasional browned areas on the leaves are caused by a fungus not yet determined. The lower, older leaves are commonly peppered on the under surface by a minute, new, hemispheriaceous fungus, *Micropeltis mucosa* Syd. This does no damage and is probably native on some related rubiaceous shrub or tree.

Euchlaena luxurians—Teosinte

This important forage crop does remarkably well in the Philippines and deserves more attention here. Ordinarily it presents a fine fresh appearance in the field. During the past year in one of our plantings a large part of the leaves turned whitish and died, destroying the planting for forage purposes. In this case the trouble appeared to be due to the new *Phyllosticta Euchlaenae* Sacc. It is possible that this occurs only during particularly unfavorable weather.

Morus alba—Mulberry

In the *Review* I pointed out the fact that during one year we had found the many dead and dying stems of mulberry in our plantation bearing several new fungi of very unusual interest. During the past year there was about the usual occurrence of dead and dying stems, but in a large gathering of these, we find only the old and well known *Diplodia Mori* West.

Musa sapientum—Banana

A blasting of the very young newly formed fruits of certain of our bananas is of common occurrence. These fruits eventually yield, in many cases, a fungus which Saccardo describes as a new species under the name *Diplodia crebra*. It is not likely, however, that this fungus is the primary cause of the trouble.

Oryza sativa—Rice

The past season was marked in this region by conspicuous and extensive damage to rice through fungus diseases. In this immediate locality from five to ten per cent was lost through these causes and from five to ten per cent more by insect work. Most conspicuous among the fungi was the false smut *Ustilaginoidea virens* (Cke.) Tak. The season seemed to be very unusually favorable to the development of this disease, and the blackened grains which finally break and give out yellowish or greenish masses of spores were all too common in the fields. Our rice is universally affected with this fungus and it only needs favorable conditions to bring it out in force.

Near the time of maturity, a whitish bloom was observed to be spreading through many panicles of rice and this was particularly conspicuous in reddish or brownish varieties. Rice affected was largely blasted and destroyed. The fungus concerned is a new species, *Oospora Oryzetorum* Sacc. In numerous cases in the fields, the tissues of glumes and caryopses turned wholly or partly white and the kernel within shriveled up. Minute fruiting bodies of a fungus finally appeared on these white areas and this has been described as a new species under the name of *Phyllosticta glumarum* Sacc. In still other cases, plants suffered through a large part of their leaves turning whitish and dying. The fungus appearing on such leaves is *Phyllosticta Miurai* Miyake, originally described from Japan.

We have been making a good many observations on the rapidity of rotting

of the rice stubble left in the fields. The common practice here, in harvesting, is to cut the panicles, leaving the bulk of the straw in the field, and this being difficult to handle with small native plows, is usually burned, on the ground. This is, of course, a destructive practice. Under favorable weather conditions the rotting of the straw proceeds rapidly, and it soon reaches a condition which favors handling by small plows. In this process a number of very interesting fungi are concerned. One of these, *Spegazzinia ornata* Sacc. was not previously known outside of Italy. Three others have proven to be new to science, *Ophiobolus oryzinus* Sacc., *Sordaria Oryzeti* Sacc., and *Coniosporium oryzinum* Sacc.

Persea gratissima—Avocado

Several plants of this valuable fruit died back very rapidly after being placed in the ground. The dead twigs were found to be completely invaded by a very interesting relative of *Fusarium*, of gelatinous consistency, which Saccardo has just described under the name *Pionnotes capillacea*.

Phaseolus vulgaris—Garden Beans

In the *Review* was mentioned the growth of *Diplodia phaseolina* Sacc. on pods of *Phaseolus lunatus*. This fungus covers the ripening pods with small black spots. We find it common also on varieties of *Phaseolus vulgaris*. In addition we find the ripening pods of *Phaseolus vulgaris* frequently covered with larger, felty, black spots, due to *Asteroma Phaseoli* Brun.

Psidium Guajava—Guava

Leaves of guava have yielded, quite locally, a very interesting new fungus, the *Pezizella ombrophilacea* of Rehm. Our guavas are commonly infested with scale insects, and these are frequently entirely killed off by a parasitic fungus. which Saccardo now determines for us as *Aschersonia paraensis* Henn. a fungus which I had collected years ago in its type locality—Para, Brazil.

Psophocarpus tetragonolobus—Calamismis

The leaves of this valuable garden plant are commonly over-run by a very curious rust—*Woroninella Psophocarpi* Rac.

Saccharum officinarum—Sugar Cane

Especially noteworthy has been our discovery during the past year that the serious rind disease caused by *Melanconium Sacchari* Cooke, is common in this region. We find several other fungi associated it. This fungus kills the half grown canes above, and eventually to the ground, blackening the pith, and fruiting on the surface in numerous exserted black, tail-like masses.

A very inconspicuous but widely spread leaf disease of cane in the Philippine exhibits itself in small reddish-bordered spots at the base of the leaf blade, both inside and out, and on the upper portion of the sheath. We have had this under observation for several years, since it seemed to us that, due to its location, it must interfere considerably with the normal function of the leaf, and that due to its very wide distribution in the Islands and its abundance, it must be of real economic importance. It appears to be a unique thing, peculiarly Philippine, and Diedicke has erected for it a new genus and species, *Bakerophoma Sacchari*.

The present cane season opens with unusual evidence of cane smut (*Ustilago Sacchari* Rabn.) in this region, many young plants being killed by it. Small boys can be sent through the fields to gather stems producing the smut and these should be burned, otherwise chronic infection will continue to exist.

Solanum Melongena—Egg Plant

Rotting fruits of egg plant have yielded a new fungus described by Diedicke under the name of *Diplodina degenerans.*

Sorghum vulgare

Our cultures of many varieties of sorghums and their allies are giving results of great promise. We were, therefore, greatly concerned over the wholesale destruction of seed during the past season by *Helminthosporium Caryopsidum* Sacc. This fungus also appeared in broom corn. Certain sorghums were so badly affected with the purple rust, *Puccinia purpurea* Cooke, during the past season as to be rendered worthless for forage.

Theobroma Cacao—Cacao

Our knowledge of the fungi directly or indirectly concerned with the enormous losses of cacao fruit which regularly occur in these Islands has been greatly advanced by the work of Messrs. Mendiola and Espino (supra). They find that the first attack on the very immature fruit in this region is usually due to *Phytophthora Faberi* Maubl. Following this, the dead and dying tissues are rapidly invaded by various other fungi, whose capacity for an initial attack is to be doubted. Following closely on the work of Phytophthora the fruit is covered by the white felt of *Fusarium Theobromae* App. and Strunk, and the brownish web of *Mycogone cervina* Ditm. var. *Theobromae* Sacc., the latter variety being new. At this stage many pods bear the small reddish or yellowish fruiting bodies of *Nectria Bainii* Massee, var. *hypoleuca* Sacc., this variety also being new. The end of the story comes in the complete invasion of the fruit by the common black, variable fungus, *Lasiodiplodia Theobromae* (Pat.) Griff. et Maubl., which, we now know, grows on many different substrata. We have found it growing actively on decaying sweet potatoes. Accompanying the *Lasiodiplodia* is a white powdery fungus which Saccardo determines as his previously described *Oospora candidula.* Replacing the *Lasiodiplodia* in chronological sequence many occasionally be found a new fungus, *Physalospora affinis* Sacc.

Through several years we have been observing the rapid and widespread death of twigs and limbs of the cacao trees of this region. These commonly bear, in abundance, the new fungus, *Botryosphaeria minuscula* Sacc. Occasionally, on the older limbs, patches may be found of the saprophytic fungus, *Cyphella Holstii* Henn. or the reddish fruiting bodies of *Ophionectria Theobromae* (Pat.) Duss.

Trichosanthes anguina—Snake Gourd or Pacupis

This cucurbit, commonly raised by the natives, is often found rotting on the vines. One such fruit, in an advanced stage, has yielded two very interesting fungi, the first representing a new genus and species, *Discothecium Bakeri* Syd. and the second a new species *Macrophoma Trichosanthis* Syd.

Vigna sp.—Cowpeas

Our reference to the common rust of these beans in the *Review*, as *Uromyces appendiculatus* (Pers.) Lk., is stated by Sydow to be incorrect, the rust really being *Uredo Vignae* Bres.

Xanthosoma sagittifolium—Yautia

We have strongly recommended certain varieties of yautia to replace the common, disease-infested Philippine gabis, since they are equally good eating, yield more heavily, and are adaptable to a wider range of conditions. Our yautia cultures showed no signs of the

Phytophthora so destructive to gabi, and were wonderfully clean and fine. However, during the past season, we find a small amount of leaf disease due to the new *Vermicularia Xanthosomatis* Sacc. This does not at all invalidate our original recommendations.

Zea Mays—Maize, Corn

The most important feature in connection with corn culture in the Philippines during the past few years has been the recognition of the presence and enormously destructive power of the Indian corn mildew, due, we suppose, to *Sclerospora Maydis* (Rac.) Butl. It attacks the young plants, which becomes chlorotic and fail to develop. Ten percent and above is commonly lost through this disease, while in some cases whole fields may be swept clean. In one interesting case, a part of a field had been subjected to wash during a heavy storm just after planting. On this area every plant was taken by the mildew, while in the remainder of the field not a half dozen died.

In one of our fields the maturing tassels of corn were found to be thoroughly infected with a *Helminthosporium* which Saccardo describes as a new species, *H. curvulum*. In another field practically all the leaves on the plants died and turned whitish before maturity, and these leaves were covered with the new fungus, *Clasterosporium Maydicum* Sacc.

As in the case of rice, so in corn, we have been interested in the fungi responsible, in part at least, for the reduction of corn trash to compost. These fungi prove to be a most interesting assemblage, including *Leptosphaeria orthogramma* (B. & Br.) Sacc., and the two new species, *Broomella Zeae* Rehm, and *Acerbia Maydis* Rehm. Others are not yet determined.

Color Variation in Seed Crops of Cultivated Legumes

By Francisco Gatchalian Galang

Thesis presented for graduation from the College of Agriculture, No. 24.

Taking the whole world into consideration, next to cereals legumes are considered the most important crop; they are extensively used, not only because of their high nutritive value, and for their oil content, but also for the fertility that they add to the soil, when used as cover crops, green manure, or planted in rotation with other crops. Some of them came into use for their power of collecting free nitrogen from the air and making it available to the plant. Representatives of the legume family are found in nearly all parts of the world, in both temperate and tropical lands. The most important ones are the beans and peas, some of which will be treated in this paper.

Although their importance is widely known throughout the world, yet in the Philippines this is not well recognized by the natives even at the present time, for they never have considered legumes as one of their important crops. In certain places they are grown for local consumption, but never to supply the demands of other countries. Even in some advanced agricultural countries, where thousands of tons of dried beans and peas are exported every year, the improvement of these plants by selection and breeding is entirely or largely neglected. I have at hand only one important study on this subject. That is *The Selective Improvement of Lima Bean* by G. W. Shaw, Cal. Agr. Exp. Station Bull. No. 238 (1913). With corn, tobacco, cotton, sugar beet, and cereals many important results have been obtained by selection and breeding of better types.

If selection and breeding should be practised in beans and peas, the following characteristics must be kept in view:—

1. Early maturity
2. Resistance to disease and to mechanical injury
3. Quality
    a. Oil
    b. Starch
    c. Nitrogen (in the beans)
    d. Number of nodules
4. Productivity

To these characteristics we can add still the selection toward uniformity of shape, size, and color in the seed; for a uniform product will easily be more attractive to the buyers and, therefore, a benefit to the growers.

A simple selection based on color is the chief aim of this experiment. Its object is to determine whether the mixed seeds in many of our cultures (College of Agriculture) result from mixtures of separate individual types (elementary species) in the cultures, or whether it is an indefinite variation within the same individual.

The materials used for the present study were the following:—

1. *Vigna sinensis*
    a. Cowpea, New Era
    b. Clay cowpea (white)
    c. Clay cowpea (red)
2. *Glycine hispida* (Soy bean)
3. *Cyamopsis psoraleoides* (Talbuda Guar)
4. *Phaseolus calcaratus* (Sinay bean)
5. *Phaseolus lunatus* (Lima bean)
6. *Psophocarpus tetragonolobus* (Calamismis)
    a. Large variety
    b. Small variety
7. *Dolichos biflorus* (Horse gram, Kulthi)
8. *Centrosema Plumieri* (Butterfly pea)
9. *Cajanus Cajan* (Pigeon pea, Caguios)

Besides the above list; sincamas (*Pachyrrhizus erosus*), and *Phaseolus vulgaris* were also planted, but both failed to survive, and many more of the other special selections also failed. These failures were due to the rainy season from June to November, and in other cases to insect pests, such as the maggots found on the root or main stem of *P. vulgaris*, and the lice and sucking insects which are the great enemies of cowpeas, and sinay bean, and to the damping-off fungus in the case of the Kulthi.

OUTLINE OF THE EXPERIMENTS

Many of the original seeds had complicated colors. To begin with, the seeds of widely different types were selected. The *Chromotaxia Seu Nomenclator Colorum, Editio Altera*, by P. A. Saccardo, 1894, was used as a color guide. The following color types are represented in the original samples chosen:—

Cowpea New Era, No. 606 F1 (a) umber with dark spots, and 606 F1 (b) chocolate brown. In the second generation of the same variety, the following were selected and planted, 606 F2 (a) umber with dark spots, 606 F2 (b) chocolate-brown; 606 F2 (c) approaching umber, 606 F2 (d) smoky, and 606 F_2 (e) sooty.

Clay cowpea (white), No. 735 F2 (a) rusty, 735 F2 (b) light leather-colored, and 735 F2 (c) cream.

Clay cowpea (white), No. 735 F2 (a) rusty 735 F2 (b) light leather-colored, and 735 F2 (c) cream.

Clay cowpea (red), No. 736 F2 (a) light-colored, 736 F2 (b) bay, 736 F2 (c) bay with dark areas, and 736 F2 (d) leather-colored with bay areas.

Soy bean, No. 217 F3 (a) amber, 217 F3 (b) yellow-whitish; and in the next generation, 217 F4 (a) amber, and 217 F4 (b) yellow whitish.

Talbuda guar, No. 609 F1 (a) drab, and 609 F1 (b) black; and the same colors were planted in the following crop.

Sinay bean, No. 213 F2 (a) light bay, 213 F2 (b) rufous, and 213 F2 (c) approaching amber; and in the next generation, 213 F3 (a) approaching amber, and 213 F3 (b) light rufous were selected.

Patani, No. 214 F2 (a) dark brick-red, 214 F2 (b) light leather-colored with black, 214 F2 (c) light leather-colored, 214 F2 (d) dark leather-colored with dark areas, and 214 F2 (e) leather-colored with dark areas. In the second generation, the following colors were selected: 214 F3 (a) leather-colored, 214 F3 (e) leather-colored with darker areas, 214 F3 (f) dark purple-mottled-leather, 214 F3 (g) chocolate-brown-mottled leather, and 214 F3 (h) black-mottled.

Calamismis large variety, No. 207 F2 (a) rufous, and 207 F2 (b) chocolate-brown in the first planting; and 207 F3 (a) bay, 207 F3 (b) pale olive-green, and 207 F3 (c) leather-colored, in the second culture.

Calamismis, small variety, No. 212 (a) chocolate, and 212 (b) sooty; and in the second generation, 212 F1 (a) sooty and 212 F1 (b) bay.

Kulthi, No. 621 F1 (a) black, 621 F1 (b) bay shading to black, 621 F1 (c) dark brick-red, 621 F1 (d) bay with black areas, and 621 F1 (e) bay. Second generation, 621 F2 (a) leather-colored, and 621 F2 (b) leather-colored with black areas.

Centrosema, No. 197 F2 (a) drab, and 197 F2 (b) dark-brick-red.

Caguios, No. 114 F2 (a) light drab with dark purple areas, 114 F2 (b) light drab, and 114 F2 (c) drab with chocolate brown areas.

METHOD OF SELECTION OF THE SECOND GENERATION

The ordinary method of selection is to wait for the total yield of all the individual plants so that the hereditary characters of each of the plants may be studied easily. By this method a planter can purify the plants more quickly and more easily. To follow the usual methods of long-continued selection was impossible in this work, because of the limited time to carry it out. In order to produce the earliest results possible from the progeny of the first generation it is necessary to get seeds from the first bearing plants. This is especially true of these beans which require a continuous harvesting for a long period of time. To these belong the patani, calamismis, guar, sinay, etc. Though the present method is crude, yet care has been taken in selecting the seeds; for some of them were from plants which had so far produced pure color up to the time of the selection; and still continued to produce pure seed of the color chosen.

METHOD OF PLANTING

All of the beans and peas cultivated in carrying out this work were planted on the acclimatization plots at the College.

The selected seeds of one kind were planted on different plots and with other varieties or species; or if they were planted in one plot, they were not placed close to the other colors of the same plant. In other words the different colors of the same plant were always separated by other plants of different species. The object of this was to prevent, as much as possible, cross pollination, between the plants of the same species or variety but with different colors. The following table serves to show the plan of the plots used:—

x x x x x x x x x x
x x x x x x x x x x x *C. Plumieri* 197 (A)
x x x x x x x x x x
x x x x x x x x x x x *C. psoraleoides* 609 (a)
x x x x x x x x x x
x x x x x x x x x x
x x x x x x x x x x
x x x x x x x x x x
x x x x x x x x x x x *P. tetragonolobus* 212 b
x x x x x x x x x x
x x x x x x x x x x
x x x x x x x x x x
x x x x x x x x x x x *P. lunatus* 214 (c)
x x x x x x x x x x
x x x x x x x x x x x *C. indicus* 114 (a)

As had been described, my plants were all scattered on different plots, so it was necessary to label them with unusual care. The plots were labeled with big letters from A-B-C etc., on a piece of board, while the plants themselves were numbered according to their real numbers in the College Records placing only a small letter after the corresponding numbers; as for example in Centrosema its College number is 197, and after this the small letters, a, b, and so on, were placed. These letters indicate how may colors had been chosen; so if one species has four letters after its own number, four different colors had been selected from it, and these are represented in my original samples.

All of the seeds of the first generation were planted at a distance of about 3 ft. between the rows and 2 ft. between the plants in the rows. But as some difficulty was found in separating the vines, the second cultures were spaced a meter between plants and rows. The purpose of this is to have the individual entirely separated; and by this means one is able to harvest the pods of each plant separately. Further to avoid mixing, especially with the climbing beans, only one seed was dropped in a hole. Even if the above precautions are taken, still frequent separation of the vines is required. This was done at least once

a week. During harvesting, each individual was numbered with tags or wooden labels, and their numbers in the field were used on sacks and envelopes when picking and threshing the harvested pods. The pods were threshed one by one in order that any mixture of color in the beans could be easily detected. Harvesting was done whenever there were many ripe pods on the plant, except in a few cases where it was necessary to pull them at once. The results are compiled in tables below. The necessary care of the plants, such as cultivation, cleaning, watering, and the placing of poles, was exercised at the proper time.

(NOTE: The immature and diseased seeds were not considered in the calculation of the percentages).

THE COWPEA (*Vigna Sinensis*)

The cowpea is called *sitao* or *paayap* by the Tagalog, though it is entirely different from our real *sitao* or *paayap*, for the latter is a pole bean while cowpea is a bush or erect one, and the beans differ in texture. When the pods of sitao are cooked green they are not so fibrous as the cowpea.

The New Era and clay cowpeas (red and white) cultivated in this work, are from the U. S. Dept. of Agriculture, and the Bureau of Agriculture. The New Era was introduced in the College September 23, 1912, and the red and white clay cowpeas November 25, 1913 and December 7, 1912, respectively.

DISCUSSION OF THE DATA FROM COWPEAS

Cowpea, "New Era":—The variation of color of this plant is caused by the rapidity of drying. If we harvest any fresh and mature pods from this plant and thresh them promptly, we will find that their seeds have almost a pure color, and this color is the sooty type; but later, as the seeds are exposed to drying, the variations in color appear; namely chocolate-brown, umber, approaching umber, smoky, and sooty. The first color is the last stage of these changes.

In planting it is not worth while to select between fresh seed of different color because all have the same percent of germination and vitality. But it is advantageous to select either smoky or the sooty type seeds when the seeds to be planted are old, because these two colors will then give a higher percent of germination than the others. This is probably due to the quick loss of the vitality of the seeds of the chocolate-brown and umber; these being the oldest among the different colors, and likely to lose their vitality before the two recommended. This happened in my first culture. A similar recommendation can be made in the case of the clay cowpeas (white and red). Of the former type, the light leather and the cream are preferable; and of the latter, light leather and leather with bay spots.

In the case of the clay varieties of cowpea, I was unable to prepare a table of their variations, because I had harvested but few pods from them and some of the seeds gotten were very badly sucked by insects. But judging by these few seeds, the rusty, light-leather, and the cream of the clay white depend upon maturity; and the same is true of the bay and light leather of the clay red, but the bay with dark areas, and the leather with bay spots seem to me to be the product of different plants. Though the record of the College shows that this plant comes with the clay red, and numbered 736, these changes took place even in my original samples.

In view of the origin of the variations in color of these three varieties of cowpeas, it is apparent that it will not pay to attempt to establish pure strains from any of the above colors, unless it be the spotted form of the clay red.

The following summaries of two tables will show the variations of the "New Era" Cowpea:

SUMMARY OF TABLE 1

11.01% of the seeds were approaching amber in the plants producing mixed colors.

19.57% of the seeds were smoky in the plants producing mixed colors.

21.22% of the seeds were sooty in the plants producing mixed colors.

SUMMARY OF TABLE 2

Showing the variations of color produced by planting the amber cowpea New Era (60 F1 (a)

0% of the plants produced pure seeds of the color planted.

7.14% of the plants produced pure sooty seeds.

92.86% of the plants produced mixed colors.

14.15% of the seeds were of the color planted (umber) in the plants producing mixed colors.

2.80% of the seeds were chocolate brown in the plants producing mixed colors.

13.37% of the seeds were approaching umber in the plants producing mixed colors.

26.13% of the seeds were smoky in the plants producing mixed color.

43.55% of the seeds were sooty in the plants producing mixed colors.

19.83% were chocolate brown seeds in the entire crop.

23.37% were umber seeds in the entire crop.

10.68% were approaching umber seeds in the entire crop.

20.64% were smoky seeds in the entire crop.

25.48% were sooty seeds in the entire crop.

THE SOY BEAN

This bean is called *utao* by the Tagalog. It is called *Ami's Bean* in the College Records, because it was first cultivated in Los Baños by a student whose name was Ami. When selections were made for this experiment it had already passed its third generation here.

In the Orient, perhaps the soy bean is next to rice in consumption. In Europe and America this plant is used principally as fodder, or forage, and as a soiling crop. It is most valuable to man and animal because of its high percentage of protein and fat. In the Philippines the bean of this plant is chiefly used in the preparation of *tahure*, a seasoning material, and as a vegetable when green. The beans have a pleasant taste when boiled, either green or ripe, but in the last state a considerable soaking is required before cooking. In China and Japan the beans are used as a substitute for grains, as rice, and for their oil.

In germination and activity of the plants, the two selected colors (yellow-whitish and amber) act alike.

At least three colors can be observed in harvesting this plant; namely, yellow-whitish, amber, yellowish-green. The last color occurs only at the time of harvest, but as to the cause of the yellow-whitish and the amber, the writer is in doubt. These colors may be due to the time of harvest, to the rapidity of drying, or to an indefinite individual variation. The two colors were often met in the same pod. If the color is due only to maturity, then this mixture in the same pod is probably caused by mechanical injury, as by insects, which suck the pods, and thus cause the attacked beans to dry quickly. If this color is caused by an indefinite variation of the same individual, then the mixture

in the same pod is perhaps due to the hereditary characters of the seed planted or to cross pollination in the field.

If an attempt is made to establish pure strains from the different colors of this plant, the yellow-whitish and the amber are the colors which are to be chosen. The tables below will serve to show the variations of this bean.

TABLE 3

Showing the variations of color produced by planting the "Amber" Soy Bean, 217-F3 (a).

No. of Plants	*No. of Pods*	*Yellow-whitish*	*Amber*	*Yellowish-green*
1	17	—	20	3
2	26	—	10	14
3	85	24	106	9
4	84	10	46	6
5	29	6	19	10
6	27	—	18	6
7	46	4	33	2
8	76	21	99	8
9	26	3	22	—
10	168	44	181	17
11	181	72	141	116
12	19	—	11	—
13	157	11	95	10
14	34	14	9	4
15	32	—	14	33
16	15	5	19	—
17	9	—	7	—
18	62	5	25	21
19	20	1	8	—
20	52	—	48	—
21	43	13	5	33
22	69	—	19	68
23	31	—	17	3
24	33	—	16	28
25	31	5	32	5
26	144	—	15	154
27	232	9	22	261
28	106	21	32	122
29	61	11	7	65
30	120	37	52	93
31	101	76	21	—
32	9	—	11	—
33	102	14	75	9
34	78	2	59	7
35	76	—	108	—
36	37	22	18	28
37	62	7	84	4
38	105	14	30	139
39	73	40	35	40
40	29	12	20	7
41	119	9	171	33
42	41	—	58	—
43	57	3	92	—
44	112	—	188	—
45	45	4	46	—
46	79	23	102	9
47	135	41	190	16
48	84	4	103	—
49	113	15	126	54
50	30	—	49	—
51	95	—	—	143
52	76	—	81	15
53	150	23	204	12
54	109	—	141	24
55	114	15	146	7
56	116	—	197	—
57	27	8	13	7
58	230	31	321	41
59	209	6	299	14
60	127	—	143	8
61	19	1	17	10
62	15	—	15	4
63	16	—	12	4
64	28	—	37	—
65	12	13	—	5
66	13	—	20	—
67	15	—	22	—
68	22	—	20	—
69	11	—	15	—
70	14	—	16	—
71	23	—	24	—
72	42	—	56	—
Total Seeds of Each Color	699	4556	1731	

23.61% of the plants produced pure seeds of the color planted.

1.39% of the plants produced pure yellowish-green seeds.

75.3% of the plants produced mixed colors.

61.66% of the seeds in the plants producing mixed colors were of the color planted.

11.74% of the seeds in the plants producing mixed colors were yellow-whitish.

26.66% of the seeds in the plants producing mixed colors were yellowish-green.

TABLE 4

Showing the variations of color produced by planting the "Yellow-white" of the Utao, 217 (b).

No. of Plants	*No. of Pods*	*Yellow-white*	*Amber*	*Yellowish-green*
1	28	—	41	7
2	17	28	—	—
3	20	23	—	—
4	13	14	—	—
5	48	2	49	8
6	36	16	29	7
7	87	5	80	11
8	74	115	—	—
9	51	4	5	68
10	35	30	11	26
11	43	33	11	—
12	19	—	27	8
13	26	27	18	4
14	49	—	4	70
15	30	—	26	15
16	35	—	22	22
17	22	—	—	33
18	37	47	—	—
19	32	40	11	—
20	18	26	8	—
21	53	12	22	47
22	54	50	15	14
23	49	41	17	7
24	111	167	16	12
25	28	16	4	—
26	22	13	—	—
27	22	3	14	—
28	20	—	23	—
29	45	17	32	13
30	50	61	—	—
31	55	19	59	4
32	64	27	78	9
33	111	163	7	—
34	150	6	180	66
35	34	40	5	—
36	22	30	—	—
37	25	—	18	—
38	30	6	26	—
39	50	23	33	18
40	35	38	5	17
41	37	49	11	—
42	29	1	33	5
43	74	16	74	6
44	85	80	43	15
45	95	—	101	32
46	91	130	—	7
47	99	29	75	37
48	145	235	—	—
49	51	14	66	—
50	83	—	117	6
51	152	241	7	6
52	260	11	361	29
53	210	19	270	11
54	90	13	181	4
55	239	—	275	88
56	70	75	9	20
57	74	74	8	5
58	22	1	11	17
59	68	—	70	15
60	66	6	54	26
61	118	129	27	13
62	63	—	12	84
63	21	1	—	31
64	29	—	25	18
65	85	—	10	109
66	94	52	16	10
67	79	116	—	—
68	105	—	26	73
69	115	52	24	57
70	94	15	138	324
Total Seeds of Each Color		2501	2960	1533
Grand Total of Each Color on Tables 3-4		3200	7516	3264

14.28% of the plants produced pure seed of the color planted.

2.86% of the plants produced pure amber seeds.

1.43% of the plants produced pure yellowish-green seeds.

81.43% of the plants produced mixed colors.

29.16% of the seeds in the plants producing mixed colors were of the color planted.

46.79% of the seeds in the plants producing mixed colors were amber.

24.05% of the seeds in the plants producing mixed colors were yellowish-green.

22.89% were yellow-whitish seeds out of the entire crop.

53.77% were amber seeds out of the entire crop.

23.34% were yellowish-green seeds out of the entire crop.

TALBUDA GUAR

The seeds which were cultivated in this work were the product of the first

generation in the College, and the first seeds were gotten from the U. S. Dept. of Agric. in 1912.

Nothing can be said about the different colors of guar as to germination and activity of the plants because they gave the same results. The variations in color of this plant are due to the age at time of harvest. For if the pods are allowed to mature and dry well before picking, their seeds will all turn black. An experiment to determine this can be seen on Table 6, plant No. 27. But if not well matured pods are harvested and allowed to dry in the sun, the color of the seeds is drab, and this is permanent. A mixture of colors is also found in the same pod but this is probably on account of injury. The steps in the changes of color run from drab to black, that is, the drab seed will first change to smoky, then approaching black, and finally to black.

SUMMARY OF TABLE 5

Showing the variations of color produced by planting drab seeds of Talbuda Guar, 609 F, (a)

.0% of the plants produced pure seesd of the color planted.

3.50% of the plants produced pure black seeds.

96.43% of the plants produced mixed colors.

23.31% of the seeds in the plants producing mixed colors were of the color planted (drab).

37.68% of the seeds in the plants producing mixed colors were black.

17.15% of the seeds in the plants producing mixed colors were approaching black.

21.86% of the seeds in the plants producing mixed colors were smoky.

SUMMARY OF TABLE 6

Showing the uariations of colors produced by planting black Talbuda Guar, 609 F, (b)

10.71% of the plants produced pure seeds of the color planted.

89.29% of the plants produced mixed colors.

58.03% of the seeds were of the color planted (black) in the plants producing mixed colors.

14.20% of the seeds were approaching black in the plants producing mixed colors.

16.33% of the seeds were smoky in the plants producing mixed colors.

11.34% of the seeds were drab in the plants producing mixed colors.

49.76% of the seeds were black in the entire crop.

14.99% of the seeds were approaching black in the entire crop.

18.34% of the seeds were smoky in the entire crop.

16.91% of the seeds were drab in the entire crop.

THE SINAY BEAN

Of the seeds produced from the different colors planted at first, almost all possessed a pure sulphur-yellow color, while a few approached amber; but as they dried up, these colors changed to dark-leather, rufous, and bay; the last color being the limit of these variations. These changes of color took place after the pods were threshed; they might also have occurred also in the pods provided the latter did not open too soon. But the pods of *sinay* open as soon as they are mature and dry, especially when the sun is hot.

The seeds harvested from the cultures of this plant were allowed to dry first for about two weeks before they were separated and tabulated, and sulphur yellow had then almost disappeared.

About a month after the tables were made, several envelopes of the seeds were opened, and it was found that further changes had taken place; that is, some of these approaching-amber changed to dark leather, and the dark leather had changed to rufous, etc. Considering the causes of the different colors of the sinay bean, it would be

a difficult matter to establish pure strains from any of the different colors of this bean in our cultures.

In my cultures of sinay, the light-bay seeds gave the poorest germination, though they were replanted several times, and given the same care as to watering, etc, as other colors. The seeds used were of the same age, and kept under the same condition as the other colors.

SUMMARY OF TABLE 7

Showing the variations of color produced by planting "Rufous" of the Sinay bean, 213 F2 (b)

No. of Plants	*Light Bay*	*Light Rufous*	*Dark leather color*	*Approaching amber*	*Sulphur yellow*
Total seeds of each color..	47	285	1484	5317	198
"Light Bay"—Sinay bean, 213 (a)					
1	127	—	—	263	—	—

0% of the plants produced pure seeds of the color planted.

4.76% of the plants produced pure dark leather-colored seeds.

4.70% of the plants produced pure approaching amber seeds.

90.48% of the plants produced mixed colors.

3.90% of the seeds were of the color planted (rufous).

0.64% of the seeds were light bay in the plants producing mixed colors.

20.33% of the seeds in the plants producing mixed colors were dark leather.

72.42% of the seeds in the plants producing mixed colors were approaching-amber.

2.71% of the seeds in the plants producing mixed colors were sulphur-yellow.

SUMMARY OF TABLE 8

Showing the variations of color produced by planting "Approaching-Amber" Sinay bean, 213 F2 (c)

No. of Plants	*Light Bay*	*Light Rufous*	*Dark leather color*	*Approaching amber*	*Sulphur yellow*
Total seeds of each color..	55	478	2077	9667	11
Grand total of each color (Tables 7-8).....	102	763	3824	14984	209

0% of the plants produced pure seeds of the color planted.

3.70 % of the plants produced pure sulphur-yellow seeds.

96.30% of the plants produced mixed colors.

78.74% of the seeds were of the color planted (amber)

0.45% of the seeds in the plants producing mixed colors were bay.

3.89% of the seeds in the plants producing mixed colors were light-rufous.

16.92% of the seeds in the plants producing mixed colors were dark leather-colored.

0.51% were light-bay seeds out of the entire crop.

3.84% were light-rufous seeds out of the entire crop.

19.24% were dark-leather seeds out of the entire crop.

1.05% were sulphur-yellow seeds out of the entire crop.

LIMA BEAN OR PATANI

This plant was introduced in the College by a student from Lipa, Batangas, in April 18, 1911.

In the Philippines this plant is cultivated chiefly for its dry beans and green pods, which are used as a vegetable by the natives, while in other countries, besides the above uses, it is also used as a cover crop and green manure.

The different colors that were found in seeds of this plant were due to two things; namely, the age at time of harvest or by the drying of the beans, or because of coming from entirely different plants. The non-spotted brick-red leather and light leather-colored were caused by the first, and this is true of the spotted brick-red, leather, and light leather with darker, black, and purple areas. These changes ordinarily occur in the seeds that are already harvested and threshed but it may happen in the pods likewise, provided the latter are not opened before these color changes are accomplished.

But the non-spotted seed, and the spotted seed with darker, black, and purple areas are strictly product of different plants. So by selection based upon any of the characters just mentioned one may expect to establish pure strains by means of continuous selection. For even in the first generation of this test it can be seen that when non-spotted types were used, the percent of them was greater than spotted ones, and vice versa, except in the case of the seeds with black areas, the products of which were badly mixed with seeds with purple areas. There should be no attempt to purify these colors for they are indefinitely variable within the same individuals.

In many cases it was observed that the non-spotted and the spotted with darker areas were found mixed on the same plant and pod, but this is probably due to hybridization of these supposedly different plants. For not only does this occur at the College but also in the original home of this patani (Lipa, Batangas).

Dark purple, chocolate-brown, and black-mottled seeds were also found. The dark purple is often found pure in single pods; but sometimes one or two different seeds are mixed with them, and the same is the case with chocolate-brown and black-mottled seeds. They are found pure in a single pod, and sometimes with the spotted black and purple seeds, but not with any other colors, such as the non-spotted, and the differently spotted seeds.

Since these three color types that occur in patani broke out from the original types, and appeared in pure forms with entirely different characters from their parents, we are lead to believe that they are mutants of the plants that produced them;—that is, the dark purple-mottled is a mutant of the plant that produced "dark-area"; and the chocolate-brown and black-mottled, of the plants which produced black and purple-area seeds. If these colors are true mutants, then one should be able to get pure strains easily.

In the chocolate-brown and black-mottled seeds, correlation exists between the stem of the plant and its seeds. A plant that possesses a violet stem will produce these two colors.

The non-spotted seeds and the spotted with darker areas have almost the same shape, but the spotted black and purple are generally flatter than the former two.

(In the calculations of the table below, the non-spotted, and the spotted with dark, black, and purple areas were taken as one color).

TABLE 9

Showing the variations of color produced by planting "Brick red" patani, 214 F2 (a)

No. of Plants	*No. of Pods*	*Dark purple mottled*	*Brick red Darker areas*	*Leather-colored Darker areas*	*Light leather Darker areas*	*Brick red*	*Leather-colored*	*Light Leather*	*Light-Leather Black spotted*
1	99	—	—	10	12	6	114	73	—
2	91	—	—	15	33	13	41	69	—
3	21	—	—	—	25	—	11	29	—
4	23	—	—	3	49	—	9	—	—
5	55	—	—	16	16	—	53	13	—
6	104	—	—	3	15	13	202	27	—
7	252	—	—	21	12	—	74	11	—
8	61	—	—	54	19	—	52	75	—
9	229	5	16	163	180	18	53	54	—

10	13	—	—	—	—	—	36	3	—
11	142	2	—	161	126	—	—	28	—
12	84	—	—	—	—	19	174	24	—
13	23	2	—	38	—	—	—	—	—
14	6	—	—	9	8	—	—	—	—
15	50	1	—	111	6	—	7	—	—
16	123	—	6	217	46	—	10	16	—
17	204	—	17	108	33	44	165	30	—
18	81	11	—	146	30	—	—	—	—
19	24	—	—	—	—	—	—	41	—
20	21	—	—	16	—	—	48	—	—
21	57	—	—	63	17	—	16	—	—
22	2	—	—	—	—	—	6	—	—
23	89	—	—	34	22	—	108	43	—
24	317	36	—	156	411	—	84	3	—
25	100	—	—	64	32	—	103	44	—
26	112	—	—	14	18	—	92	111	—
27	19	—	—	4	10	4	8	—	—
28	61	—	—	28	—	—	46	26	—
29	11	—	—	—	—	7	14	—	—
30	114	—	—	—	—	15	128	297	1
31	1	—	—	—	—	—	3	—	—
32	159	—	—	—	—	—	5	397	—
33	33	—	—	—	25	3	21	34	—
34	809	—	—	59	161	122	566	975	—
35	117	15	—	73	121	—	—	—	—
36	154	5	—	74	195	—	9	28	—
37	117	—	—	—	—	—	180	68	—
38	150	—	—	—	—	10	127	190	—
39	44	—	—	7	7	—	36	20	—
40	117	—	—	32	59	—	65	123	—
41	47	—	—	10	10	—	43	56	—
42	380	—	—	—	9	28	354	456	—
43	67	—	—	—	—	19	68	50	—
44	20	—	—	—	—	—	25	41	—
45	116	—	—	—	39	32	84	91	—
46	18	3	—	10	31	3	—	—	—
47	62	—	—	4	—	—	52	98	—
48	106	—	—	19	46	17	40	94	—
49	104	—	—	—	55	18	70	70	—
50	272	5	—	13	109	25	121	251	—
51	298	—	3	5	74	34	132	392	—
52	391	—	—	24	59	34	356	388	—
53	65	—	—	—	—	5	—	40	110
54	91	—	—	—	43	—	—	180	—
55	169	1	—	3	55	7	52	239	—
56	112	—	—	1	15	17	33	194	—
57	55	—	—	—	—	4	26	110	—
58	250	—	—	28	125	11	114	282	—
Total seeds of each color...	86	42	1852	2358	528	4246	5794	113	

18.97% of the plants produced pure seeds of the color planted (non-spotted).

81.03% of the plants produced mixed colors.

67.07% of the seeds in the plants producing mixed colors (non-spotted).

31.46% of the seeds in the plants producing mixed colors were dark-mottled.

0.84% of the seeds in the plants producing mixed colors were black-mottled.

0.63% of the seeds in the plants producing mixed colors were dark purple-mottled.

TABLE 10

Showing the variations of color produced by planting "Light leather-black mottled" patani, 214 F2 (b)

No. of Plants	*No. of Pods*	*Dark purple mottled*	*Leather-colored — Darker Areas*	*Light leather — Darker Areas*	*Leather-colored*	*Light leather-colored*	*Bay — Black Areas*	*Leather-colored — Black Areas*	*Light leather — Black Areas*	*Black Mottled*	*Chocolate brown mottled*	*Leather-colored — Purple Areas*	*Light leather — Purple Areas*
1.....	75	—	53	—	—	—	—	15	21	—	2	—	—
2.....	5	—	—	—	—	—	—	—	7	—	—	—	—
3.....	18	—	—	3	—	—	14	3	6	6	—	—	—
4.....	45	25	—	—	—	—	—	—	—	—	6	—	—
5.....	12	—	7	4	—	—	7	—	1	—	2	3	—
6.....	31	—	—	—	—	—	52	15	—	—	—	—	—
7.....	70	—	—	—	—	—	—	83	—	4	—	—	—
8.....	50	—	—	—	40	30	—	—	11	—	4	—	—
9.....	130	—	—	—	35	152	—	27	33	—	2	—	—
10.....	147	—	—	—	—	—	—	30	271	30	66	—	—
11.....	138	—	—	—	49	—	—	—	170	27	8	7	—
12.....	184	4	—	—	—	—	—	14	—	44	79	158	19
13.....	201	10	—	—	—	—	—	—	31	8	186	299	70
14.....	45	—	—	—	—	—	—	—	4	10	15	46	16
15.....	125	—	—	—	—	—	—	—	38	20	27	132	38
16.....	106	—	—	—	—	—	—	—	14	8	47	138	35
17.....	161	—	—	—	—	—	—	—	1	—	121	183	35
18.....	208	—	—	—	—	—	—	3	—	—	194	249	43
19.....	158	—	—	—	—	—	17	—	15	20	115	141	59
20.....	107	—	—	—	—	—	—	—	42	17	50	92	30
21.....	11	—	—	—	—	—	—	—	—	—	4	6	10
22.....	66	—	—	—	—	—	—	—	21	8	40	39	38
23.....	31	—	—	—	—	—	—	—	—	1	29	25	14
24.....	70	—	—	—	—	—	5	—	14	—	38	48	21
25.....	126	—	—	—	—	—	—	—	15	20	82	121	23
26.....	9	—	—	—	—	—	—	—	—	—	12	5	5
27.....	45	—	—	—	—	—	—	—	8	10	32	51	26
Total seeds of each color.....		39	60	7	124	182	95	190	723	223	1161	1743	492

7.41% of the plants produced pure seeds of the color planted. (spotted black).

92.59% of the plants produced mixed colors.

18.81% of the seeds in the plants producing mixed colors were of the color planted (spotted-black).

0.79% of the seeds in the plants producing mixed colors were dark purple-mottled.

1.35% of the seeds in the plants producing mixed colors were spotted with darker areas.

6.15% of the seeds in the plants producing mixed colors were non-spotted.

4.49% of the seeds in the plants producing mixed colors were black-mottled.

23.39% of the seeds mottled in the plants producing mixed colors were chocolate-brown

45.02% of the seeds in the plants producing mixed colors were spotted with purple areas.

TABLE 11

Showing the variations of color produced by planting "Light-leather" patani, 214 F2 (c)

No. of Plants	No. of Pods	Dark-purple, Mottled	Brick-red, darker areas	Leather-colored, darker areas	Light-leather, darker areas	Brick-red	Leather-colored	Light-leather	Light-leather, black-postted
1	39	2	—	41	92	—	—	10	—
2	170	1	—	—	—	—	—	200	161
3	6	—	—	9	—	—	—	—	3
4	46	—	—	—	—	—	—	51	22
5	68	—	—	—	1	6	60	84	—
6	24	—	—	—	—	8	21	18	—
7	55	—	—	—	9	14	—	73	—
8	66	—	—	21	57	—	10	64	—
9	50	—	—	14	38	—	14	20	—
10	38	—	—	10	4	6	39	19	—
11	52	—	—	11	—	—	29	55	—
12	41	—	—	—	8	—	27	29	—
13	34	—	—	—	—	2	—	—	27
14	17	—	—	12	12	—	—	—	—
15	35	—	—	15	17	6	17	28	—
16	117	—	—	—	—	—	17	62	41
17	335	—	13	24	186	17	64	603	—
18	74	—	—	4	30	—	37	85	—
19	170	18	—	—	121	—	15	230	—
20	33	—	—	—	—	—	—	80	—
21	71	—	—	—	78	—	—	90	—
22	106	—	—	—	—	—	18	222	—
23	154	—	—	—	26	—	41	316	—
24	257	—	—	8	41	34	118	459	—
25	565	—	—	15	68	42	392	716	—
26	276	—	—	56	64	16	123	356	—
27	215	12	38	292	37	—	11	11	—
28	45	—	—	—	26	—	—	194	—
29	27	—	—	—	6	—	—	74	—
30	152	45	—	25	264	—	—	10	—
31	80	7	3	—	24	—	26	135	—
32	23	—	—	—	2	—	2	49	—
33	224	50	13	—	465	—	—	—	—
34	408	—	—	—	—	34	276	565	—
35	2	—	—	—	—	—	—	3	—
36	271	—	—	49	64	—	158	360	—
37	39	4	—	—	39	7	7	44	—
38	74	—	—	—	—	—	24	51	106
39	71	—	—	7	30	—	32	135	—
40	88	—	—	14	88	—	42	90	—
41	147	—	—	—	—	20	83	462	—
42	167	—	—	11	26	16	134	265	—
43	28	—	—	—	—	8	26	35	—
44	13	—	—	—	28	—	—	12	—
45	9	—	—	—	11	4	—	8	—
46	50	—	—	42	91	—	—	—	—
47	62	6	—	53	77	—	—	—	—
48	35	—	—	—	—	—	—	102	—
49	1	—	—	—	—	—	—	3	—
50	180	—	—	15	32	21	114	274	—
51	172	—	—	21	103	—	165	211	—
52	121	2	—	7	14	—	59	232	—
53	50	8	—	80	15	—	10	11	—
54	106	—	—	9	18	—	63	189	—
55	70	—	—	—	8	—	71	124	—
56	34	—	—	—	—	—	25	69	—
57	119	—	—	—	—	—	90	102	—
58	114	—	—	—	—	32	135	163	—
59	25	—	—	—	—	—	4	59	—
60	30	—	—	—	—	—	7	79	—
61	105	—	1	40	30	5	57	69	—
62	18	—	—	—	—	34	16	—	—
63	152	—	—	—	5	87	122	174	—
64	15	—	—	—	—	11	21	—	—

TABLE 11.—*Continued*

Showing the variations of color produced by planting "Light-leather" patani, 214 F2 (c)

No. of Plants	*No. of Pods*	*Dark-pupple, Mottled*	*Brick-red, darker areas*	*Leather-colored darker areas*	*Light-leather, darker areas*	*Brick-red*	*Leather-colored*	*Light-leather*	*Light-leather, black-spotted*
65	13	—	—	12	1	2	10	5	—
66	28	—	2	2	—	15	32	—	—
67	4	—	—	—	—	3	—	—	—
68	211	—	—	—	—	—	61	506	—
69	32	—	—	—	—	6	18	21	—
70	7	—	—	1	—	—	12	1	—
71	19	—	—	4	—	11	5	34	—
72	2	—	—	—	—	—	—	2	—
73	13	—	—	—	—	5	19	—	—
74	155	—	—	9	2	114	111	154	—
75	37	—	—	—	—	4	8	—	—
Total seeds of each color...	153	70	933	2358	590	3108	9767	360	

26.67% of the plants produced pure seeds of the color planted.

4.00% of the plants produced pure spotted seeds (darker areas).

69.33% of the plants produced mixed colors.

73.42% of the seeds in the plants producing mixed colors. were of the color planted (non-spotted).

1.13% of the seeds in the plants producing mixed colors were dark purple-mottled.

22.78% of the seeds in the plants producing mixed colors were spotted with black areas.

TABLE 12

Showing the variations of color produced by planting "Dark leather with darker areas" patani, 214 F2 (d)

No. of Plants	*No. of Pods*	*Dark purple Mottled*	*Brick red darker Areas*	*Leather colored darker Areas*	*Light leather darker Areas*	*Brick red*	*Leather colored*	*Light leather*
1	6	30	4	—	266	—	—	—
2	79	—	—	—	46	26	14	137
3	8	7	—	—	3	—	23	1
4	19	2	—	3	40	—	—	—
5	118	28	7	6	339	—	—	1
6	21	—	—	20	15	—	9	—
7	470	70	11	207	882	—	—	—
8	84	5	10	21	119	—	15	4
9	31	4	—	5	74	—	—	—
10	86	41	—	—	260	—	—	—
11	79	—	—	3	7	21	94	33
12	1	—	3	—	—	—	—	—
13	39	1	—	59	9	—	8	3
14	37	—	—	—	—	22	31	8
15	3	—	—	—	6	—	3	—
16	274	28	61	482	83	—	—	—
17	305	6	108	190	65	98	122	33
18	21	—	—	—	—	3	—	31
19	60	10	18	49	24	—	—	1
20	96	—	—	110	32	—	60	19
21	69	—	12	60	52	—	13	7
22	186	17	20	345	48	—	—	—
23	336	22	56	598	113	—	14	6
24	86	23	—	—	213	—	—	—
25	4	1	—	—	10	—	—	—
26	14	—	—	—	14	—	—	34
27	7	—	—	—	10	—	—	—
Total seeds of each color...	295	310	2158	2731	170	406	318	

7.41% of the plants produced pure seeds of the color planted (spotted with darker areas).

7.41% of the plants produced pure non-spotted seeds.

85.18% of the plants produced mixed colors.

82.58% of the seeds in the plants producing mixed colors were of the color planted (spotted with darker areas).

4.69% of the seeds in the plants producing mixed colors were dark purple-mottled.

12.73% of the seeds in the plants producing mixed colors were non-spotted.

TABLE 13

Showing the variations of color produced by planting "Leather with darker areas" patani, 214-F2 (e)

No. of Plants	*No. of Pods*	*Dark purple Mottled*	*Brick red darker Areas*	*Leather colored darker Areas*	*Light leather darker Areas*	*Brick red*	*Leather colored*	*Light leather*
1	40	3	—	76	13	—	—	—
2	223	8	—	492	39	—	—	—
3	64	11	—	95	41	—	—	—
4	59	2	—	113	15	—	—	—
5	22	5	—	20	28	—	—	—
6	191	—	—	—	33	27	321	111
7	155	47	22	177	134	—	—	—
8	91	12	—	140	37	—	—	—
9	72	17	3	102	30	—	—	—
10	39	13	—	79	19	—	—	—
11	34	5	—	21	68	—	—	—
12	56	2	6	119	15	—	—	—
13	153	33	—	266	79	—	—	—
14	264	96	—	275	214	—	—	—
15	43	5	—	93	18	—	—	—
16	122	1	—	159	56	—	—	—
17	58	16	—	49	72	—	—	—
18	66	—	—	138	28	—	—	—
19	48	3	—	18	97	—	—	—
20	66	7	—	117	15	—	—	—
21	145	—	6	98	42	13	109	41
22	16	—	—	5	—	—	22	4
Total seeds of each color...		286	37	2652	1203	40	500	189
Grand total of each color..		859	459	7655	8757	1328	8384	16250

95 bay, black-mottled; 190 leather, black-mottled; 1196 light-leather, black-mottled; 223 black-mottled; 1161 chocolate-brown mottled; 1743 leather, purple-mottled; 492 light leather, purple-mottled.

4.54% of the plants produced pure seeds of the color planted. (spotted with darker areas).

95.46% of the plants produced mixed colors.

79.04% of the seeds in the plants producing mixed colors were of the color planted (spotted with darker areas).

5.90% of the seeds in the plants producing mixed colors were dark purple-mottled.

15.06% of the seeds in the plants producing mixed colors were non-spotted.

1.76% of the seeds were dark purple mottled in the entire crop.

34.58% of the seeds were spotted with darker areas in the entire crop.

53.21% of the seeds were non-spotted in the entire crop.

3.03% of the seeds were spotted with black areas in the entire crop.

0.46% of the seeds were black-mottled in the entire crop.

2.38% of the seeds were chocolate-brown-mottled in the entire crop.

4.58% of the seeds were spotted with purple areas in the entire crop.

CALAMISMIS

The large variety produces from 1 to 16 seeds, the small one, from 1 to 14, in each pod. Both varieties have a flowering season beginning in September. Ripe pods can be harvested 1 or 1½ months after blooming.

The Filipinos use the green pods as vegetables, and in other countries, as in India, this plant is cultivated simply for its tuberous roots.

The College got the first seeds of the large and small variety from Pangasinan and also from Lipa, Batangas, in 1911.

DISCUSSION OF THE DATA FROM CALAMISMIS

SMALL VARIETY:—The variabilty of the seeds of this plant is due to the stage of dryness of the seeds; for if the pods are allowed to remain for a long time on the plant their seeds when threshed possess almost a pure color, and this color is the sooty type. Then, as soon as they are exposed to the air, this color type of the seeds begins to vary from sooty to rufous, bay and to chocolate-brown.

By the different stages of the changes in color of the seeds one may be able to select the mature seeds, because the well-matured seeds, besides being shiny, are also chocolate brown.

Large variety:—The change of the colors of this variety is unlike that of the former variety because the variation may take place both in and outside of the pods. These variations are caused either by the age at time of harvest, or by the degree of dryness of the seeds.

Since the tables merely express the degree to which the seeds had assumed their final shade when they were examined, it is not worth while to reproduce them. They bear the numbers 14, 15 and 16.

KULTHI OR HORSE GRAM

Kulthi is used for stable grain, for fodder, and as green manure. It is a good catch crop. The peas are boiled or fried and eaten with rice or other foods in some countries. The flowers are used in the preparation of sweetmeats.

The spotted and non-spotted kulthi seems usually to come from separate individuals though it will be seen from the table below that these two characters of these seeds are sometimes found in one plant. This is probably on account of the mixture of the plants. Evidence is presented in tables 18 and 19; when non-spotted seeds were planted the percent of the plants producing pure non-spotted seeds was greater, and even in the plants producing mixed colors the non-spotted seeds had a greater percent than the spotted type.

From the cultures of the spotted kulthi no seeds were harvested. But in Table 17 it seems doubtful whether all of the plants were offspring of spotted seeds. The black seeds of kulthi were not due either to stage of dryness or degree of maturity of the seeds, but to fungus attack. This can be proved by the small percentage of germination of the black seeds; in the first harvest of this plant no black seeds were found. As the fungus begins to attack the seeds, some of them turn black.

TABLE 17

Showing the variations of color produced by planting "Black" kulthi, 621-F1 (a)

No. of Plants	*No. of Pods*	*Bay bearing to black*	*Bay*	*Rufous*	*Leather colored*	*Bay black Areas*	*Rufous black Areas*	*Leather black Areas*	*Sooty black Areas*
1.....	29	—	—	—	—	17	61	2	—
2.....	369	—	—	—	—	1110	98	—	51
3.....	276	88	—	13	—	798	287	—	16
4.....	186	—	22	504	35	—	—	—	—
5.....	77	16	—	—	—	105	80	—	47
6.....	35	—	—	—	—	47	—	17	51
7.....	1073	35	66	9	—	698	2832	767	273
8.....	805	—	110	1135	301	162	801	340	107
9.....	336	21	—	7	—	437	666	166	55
10.....	195	—	—	271	318	—	—	65	49
11.....	180	—	—	—	36	14	88	418	149
Total seeds of each color...		160	198	1939	690	3388	4913	1675	798

0% of the plants produced pure seeds of the color planted.

27.27% of the plants produced pure spotted seeds.

9.09% of the plants produced pure non-spotted seeds.

63.64% of the plants produced mixed colors.

1.16% of the seeds in the plants producing mixed colors were bay bearing to black.

1.44% of the seeds in the plants producing mixed colors were bay.

14.09% of the seeds in the plants producing mixed colors were rufous.

5.03% of the seeds in the plants producing mixed colors were leather-colored.

24.66% of the seeds in the plants producing mixed colors were bay with black areas.

35.74% of the seeds in the plants producing mized colors were leather with black areas.

12.18% of the seeds in the plants producing mixed colors were leather with black areas.

5.75% of the seeds in the plants producing mixed colors were sooty with black areas.

By combining the above calculations we get the following:

21.62% of the seeds were non-spotted in the plants producing mixed colors.

78.33% of the seeds were spotted with black in the plants producing mixed colors.

TABLE 18

Variations of color produced by planting "Bay bearing to black" kulthi, 621-F1 (b)

No. of Plants	*No. of Pods*	*Bay bearing to black*	*Bay*	*Rufous*	*Leather colored*	*Bay black Areas*	*Rufous black Areas*	*Leather black Areas*	*Sooty black Areas*
1.....	174	17	55	501	21	—	—	—	—
2.....	183	23	120	422	13	—	—	—	—
3.....	448	485	618	231	77	—	—	—	—
4.....	350	—	22	260	532	17	—	111	89

TABLE 18

Variations of color produced by planting "Bay bearing to black" kulthi, 621-F1 (b)

No. of Plants	No. of Pods	Bay bearing to black	Bay	Rufous	Leather colored	Bay black Areas	Rufous black Areas	Leather black Areas	Sotty black Areas
5	454	—	90	634	828	—	—	—	—
6	59	—	—	3	71	—	—	58	30
7	252	—	25	174	513	—	—	—	—
8	62	—	—	24	155	—	—	—	4
9	336	—	196	328	209	54	—	84	31
10	27	—	—	17	65	—	—	—	—
11	191	—	14	173	532	—	—	—	—
12	583	—	68	367	1732	—	—	—	—
13	352	—	51	302	798	—	—	—	—
14	378	—	21	313	1004	—	—	—	—
15	99	—	118	90	92	—	—	—	—
16	313	—	212	483	318	—	—	—	—
17	204	—	143	365	126	—	—	—	—
18	126	24	94	115	203	—	—	—	—
19	188	—	118	242	252	—	—	—	—
20	124	23	116	71	36	—	—	—	—
21	147	20	129	119	77	—	—	—	—
22	151	—	61	181	143	14	—	4	—
23	140	16	6	—	—	217	—	123	—
24	52	—	64	39	65	—	—	—	—
25	189	32	218	65	35	55	87	—	—
26	74	12	41	63	—	—	31	28	23
27	94	—	45	37	42	163	87	34	14
28	140	—	—	—	—	111	71	356	20
29	17	—	31	19	—	—	—	—	—
30	92	16	60	116	93	15	—	—	—
31	291	35	108	83	12	134	19	185	19
32	114	—	30	57	182	—	—	64	—
33	54	7	16	14	24	16	9	55	7
34	97	—	13	—	106	21	—	149	13
35	63	—	35	41	107	—	—	—	—
36	143	41	89	170	97	—	5	—	—
37	9	—	4	4	10	—	—	2	—
38	254	—	8	81	699	—	—	—	—
39	355	—	74	697	409	—	—	—	—
40	527	—	88	521	938	—	—	13	—
41	95	—	144	945	2081	—	—	—	—
42	136	—	—	61	321	—	19	8	23
Total seeds of each color...		751	3345	8428	13018	717	328	1274	273

54.76% of the plants produced pure non-spotted seeds.

45.24% of the plants produced mixed colors.

2.67% of the seeds of the plants producing mixed colors were of the color planted (bay bearing to black).

11.18% of the seeds on the plants producing mixed colors were bay.

29.96% of the seeds of the plants producing mixed colors were rufous.

46.23% of the seeds of the plants producing mixed colors were leather-colored.

2.54% of the seeds of the plants producing mixed colors were bay with black areas.

1.17% of the seeds of the plants producing mixed colors were rufous with black areas.

4.53% of the seeds of the plants producing mixed colors were leather with black areas.

0.97% of the seeds of the plants producing mixed colors were sooty with black areas.

By combining the above calculations into two types only non-spotted and spotted) we have the folllowing:—

90.04 % of the seeds of the plants producing mixed colors were non-spotted.

9.11% of the seeds of the plants producing mixed colors were spotted with black.

TABLE 19

Variations of color produced by planting "Dark-brick-red" kulthi, 621F1 (c)

No. of Plants	*No. of Pods*	*Bay bearing to black*	*Bay*	*Rufous*	*Leather colored*	*Bay black Areas*	*Rufous Black Areas*	*Leather black Areas*	*Sooty black Areas*
1	135	—	33	49	319	—	—	—	—
2	234	—	97	449	441	—	—	—	—
3	223	—	290	283	193	—	—	—	—
4	321	—	114	461	631	—	—	—	—
5	639	78	262	523	1189	—			—
6	733	—	403	756	1656	—	—	—	—
7	241	—	37	105	731	—	—	—	—
8	83	—	22	45	219	—	—	—	—
9	88	—	14	10	259	—	—	—	—
10	94	—	32	75	274	—	—	—	—
11	81	—	15	41	220	—	—	—	—
12	371	—	24	267	1071	—	—	—	—
13	279	—	79	180	854	—	—	3	—
14	269	—	—	79	1014	—	—	—	—
15	295	13	55	236	756	—	—	—	—
16	282	—	40	237	788	—	5	—	—
17	300	—	44	252	837	—	—	—	—
18	120	—	—	20	203	8	49	49	44
19	184	—	—	121	601	—	—	—	—
20	133	—	—	92	302	—	—	28	—
21	112	—	—	90	109	—	6	—	—
22	148	—	—	69	74	—	61	147	106
23	53	—	—	4	145	—	8	22	—
24	160	—	—	59	452	—	—	—	—
25	126	—	4	58	85	27	—	147	11
26	123	—	18	52	192	—	—	14	—
27	32	—	—	12	83	—	—	—	3
28	154	—	14	99	354	3	—	18	4
29	192	—	27	125	357	18	45	57	54
Total seeds of each color...		91	1624	4848	14409	56	174	485	222
Grand total of each color..		1002	5167	15215	28117	4161	5415	3434	1293

58.62% of the plants produced pure non-spotted seeds.

41.38% of the plants produced mixed colors.

0.42% of the seeds of the plants producing mixed colors were bay bearing to black.

0.41%of the seeds of the plants producing mixed colors were bay.

22.14% of the seeds of the plants producing mixed colors were rufous.

65.75% of the seeds of the plants producing mixed colors were leather-colored.

0.25% of the seeds of the plants producing mixed colors were bay with black areas.

0.79% of the seeds of the plants producing mixed colors were rufous with black areas.

2.22% of the seeds of the plants producing mixed colors were leather with black areas.

1.01% of the seeds of the plants producing mixed colors were sooty with black areas.

By combining the above calculations into two types we have the following:—

95.72% of the seeds of the plants producing mixed colors were non-spotted.

4.27% of the seeds of the plants producing mixed colors were spotted with black.

1.57% of the entire crop of seeds: were by a bearing to black seeds,

8.09% were bay seeds.

23.84% were rufous seeds.

44.07% were leather seeds.

6.52% were bay with black areas.

8.48% were rufous with black areas.

5.38% were leather with black areas.

2.03% were sooty with black areas.

By combining the above into two color types we have the following:—

77.57% of the seeds were non-spotted.

22.41% of the seeds were spotted with black areas.

THE BUTTERFLY PEA

On account of the vegetative growth, of this plant, we were unable to harvest the seeds of each plant separately. In this case all the plants in a plot were harvested together and their seeds were presented on the table as one plant for comparison with the other species in this work. The total plants on each plot were indicated by the number in the first column of their tables.

In the study of the variability in color of the seeds of this plant nothing more is to be described because it has the same cause as in some of the foregoing legumes; namely, the age at time of harvest.

TABLE 20

Showing the variations of color produced by planting "Drab" butterfly pea, 197 F2 (a).

No. of Plants	*No. of Pods*	*Drab*	*Dark brick red*
27	328	2527	9
18	457	4005	31
30	582	2883	389
Total seeds of each color..		9415	429

94.32% of the seeds were of the color planted (drab),

5.68% of the seeds were brick red in the plants producing mixed colors.

TABLE 21

Showing the variations of color produced by planting "Dark brick-red" butterfly pea, 197 F2 (b)

No. of Plants	*No. of Pods*	*Drab*	*Dark brick red*
16	407	1996	11
18	149	1365	—
18	654	5684	23
30	864	6116	114
27	1023	8662	81
Total seeds of each color..		23823	229
Grand Total of each Color		33238	658

99.04% of the seeds were drab.

.96% of the seeds were brick red.

98.06% of the seeds were drab out of the entire crop.

1.94% of the seeds were dark brick red out of the entire crop.

THE PIGEON PEA, OR CAGUIOS

The peas are used when green as well as when ripe and sometimes they are made into cakes. The leaves are used for fodder.

The first seeds of the College were obtained from Lipa, Batangas, in 1911. The seeds cultivated in this work were the product of the second generation.

This is the only one among the plants cultivated in this experiment in which the different colors found in its seeds had

been reported (See THE PHIL. AGRIC. AND FOR., Vol. 2, No. 1-3). Here it was said that white, black, and mottled seeds were occurring on a single plant. But in the study of this species the colors found are drab with chocolate-brown areas, light drab with dark purple areas, light drab, and yellow-whitish. These different colors, as is seen in the tables, were the products of different individuals The results obtained lead us to believe that they are the seed of different varieties of *Cajanus indicus*; though in some cases, some of the plants produced mixed colors, probably due to the mixture of the plants, here or in their original home, and consequent cross pollination. There is no doubt that at least four distinct colors of the seeds can be established by continuous selection.

As to other differences between the plants that produced the different colors, nothing was observed. The chocolate-brown and the yellow-whitish seeds are usually flatter than the two other colors. And the pods of the spotted seeds were generally larger than the two others (non-spotted).

TABLE 22

Variations of color produced by planting "Light drab with dark purple areas" pigeon pea, 114-F2 (a)

No. of Plants	*Yellow whitish*	*Drab with chocolate brown areas*	*Light drab and dark-purple areas*	*Light drab*
1	—	795	—	—
2	—	—	—	418
3	—	—	931	—
4	—	—	252	—
5	—	—	—	504
6	—	—	1013	—
7	—	445	—	—
8	—	—	—	1429
9	—	—	—	2397
10	—	—	1683	—
11	1369	—	—	—
12	—	—	—	542
13	—	692	—	—
14	—	—	493	—
15	—	—	1305	—
16	—	—	3115	—
17	—	—	526	—
18	—	—	—	3993
19	—	—	—	1622
20	26	1265	481	—
21	2419	—	—	—
22	—	—	—	6323
23	—	—	—	4474
24	—	—	2312	31
25	—	—	—	563
26	—	—	477	86
27	—	—	—	140
28	—	—	202	—
29	—	—	128	—
30	—	—	110	—
31	—	—	—	867
32	—	—	—	3842
33	—	1735	—	—
34	—	—	—	3965
35	—	798	—	—
36	—	—	—	7346
37	—	—	—	1833
38	—	—	—	1360
39	1261	419	—	—
40	—	—	—	2163
41	—	399	—	—
42	—	—	288	—
43	—	—	—	1187
44	—	—	350	682
45	156	—	382	58
46	154	—	2013	40
47	—	1381	651	—
48	165	—	—	—
49	—	—	—	415
50	—	—	—	923
51	1125	—	—	—
52	—	219	—	—
53	—	1760	—	—
54	—	1047	—	—
55	—	3287	—	—
56	—	—	—	1436
57	—	—	—	1494
58	—	—	—	6200
59	—	—	—	1081
60	6644	—	—	—
61	—	587	—	—
62	—	397	—	—
63	286	—	—	—
64	—	306	—	—
65	80	—	—	—
66	—	—	405	—
67	—	—	88	—
68	—	40	—	—
Total seeds of each color	13728	12572	17005	57414

19.11% of the plants produced pure seeds of the color planted (light drab with dark purple areas.)

20.59% of the plants produced pure drab with chocolate-brown areas seeds.

36.76% of the plants produced pure light-drab seeds.

10.30% of the plants produced pure yellow-whitish seeds

13.24% of the plants produced mixed colors.

54.26% of the seeds of the plants producing mixed colors were of the colors planted (light drab with dark purple areas)

25.37% of the seeds of the plants producing mixed colors were drab with chocolate-brown areas.

7.22% of the seeds of the plants producing mixed colors were light drab.

13.15% of the seeds on the plants producing mixed colors were yellow-whitish.

TABLE 23

Variations of color produced by planting "Light-drab" pigeon pea, 114 F2 (b)

No. of Plants	*Drab with chocolate-brown areas*	*Light-drab with dark-purple areas*	*Light-drab*	*Yellow-whitish*
1	—	—	8072	—
2	—	—	297	—
3	—	—	2995	—
4	—	—	3123	—
5	2158	—	—	—
6	—	—	2477	—
7	—	—	877	—
8	—	—	865	—
9	—	—	1358	—
10	—	—	1947	—
11	—	—	2255	—
12	—	—	—	1810
13	—	—	—	1359
14	—	—	—	2570
15	—	—	5433	—
16	—	—	—	3105
17	—	—	—	1816
18	—	—	1877	—
19	—	—	3205	—
20	—	—	695	—
21	—	—	602	—
22	—	—	—	2476
23	—	—	2171	—
24	—	—	760	—
25	—	—	3868	—
26	—	—	1426	—
27	—	—	77	—
28	—	—	5344	—
29	—	—	751	—
30	—	—	—	152
31	—	725	—	—
32	—	—	—	268
33	—	—	—	93
34	—	—	520	—
35	—	—	328	—
36	—	—	587	—
37	—	—	250	—
38	—	—	4450	—
39	—	—	195	—
40	—	—	1562	—
41	—	—	—	39
42	—	—	1503	—
43	—	—	145	—
44	—	—	—	1698
45	—	—	984	—
46	—	—	—	1406
47	—	—	2919	—
48	—	—	3365	—
49	—	—	993	—
50	—	—	2702	—
51	—	—	3997	—
52	—	—	—	2523
Total seeds of each color	2158	725	74275	19315

71.16% of the plants produced pure seeds of the color planted

1.92% of the plants produced pure drab with chocolate-brown-aread seeds.

1.92% of the plants produced pure light drab with dark purple-aread seeds.

25.00% of the plants produced pure yellow-whitish seeds.

TABLE 24

Variations of color produced by planting "Drab with chocolate-brown areas" pigeon pea," 114 F2 (c)

No. of Plants	*Drab with chocolate-borwn areas*	*Light-drab with dark-purple areas*	*Light-drab*	*Yellow-whitish*
1	—	6015	—	34
2	—	—	—	1567
3	2201	8	—	12
4	1467	—	—	—
5	—	10	3092	—
6	1557	—	—	—
7	—	—	—	665
8	5964	—	—	—
9	1516	—	—	—
10	—	—	115	—
11	—	—	—	2418
12	3007	—	—	—
13	—	—	—	3829
14	1640	—	—	—
15	—	43	—	—
16	18	—	—	71

17.....	35	—	—	88
18.....	488	—	—	—
19.....	1602	—	—	—
20.....	1323	—	—	—
21.....	—	—	—	900
22.....	3089	—	—	—
23.....	3312	—	—	—
24.....	—	—	1508	—
25.....	6155	—	—	—
26.....	4130	—	—	—
27.....	—	—	—	3284
28.....	1388	—	—	—
29.....	514	—	—	—
30.....	—	—	—	238
31.....	—	—	1125	—
32.....	318	—	—	—
33.....	556	—	—	—
34.....	—	—	—	3168
35.....	—	—	—	840
36.....	—	—	—	1083
37.....	—	—	—	702
38.....	608	—	—	—
39.....	3065	—	—	—
40.....	1146	—	—	—
41.....	—	—	—	495
42.....	—	—	—	2554
43.....	—	—	—	1588
44.....	—	—	—	237
Total seeds of each color.....	44162	6076	5840	23773

45.46% of the plants produced pure seeds of the color planted (drab with chocolate-brown areas).

2.27% of the plants produced pure "light drab with dark purple areas" seeds.

6.82% of the plants produced pure light drab seeds.

34.09% of the plants produced pure yellow-whitish seeds.

11.36% of the plants produced mixed colors.

19.46% of the seeds of the plants producing mixed colors were of the color planted (drab with chocolate-brown areas).

52.08% of the seeds of the plants producing mixed colors were light drab with dark purple areas.

26.69% of the seeds of the plants producing mixed colors were light-drab.

1.77% of the seeds of the plants producing mixed colors were yellow-whitish.

SUMMARY

Summarizing the results of this study and putting them into the form of a general statement, we may say that:—

1. It is doubtful whether pure strains are to be sought by selection from the different colors of our cultures of New Eraco wpea, Talbuda Guar, sinay bean, large and small variety of calamismis, and butterfly pea.

2. By judicious individual selections it is probable that pure strains can be established from the yellow-whitish, and amber soy beans.

3. In the case of the patani, kulthi, and pigeon pea, it seems quite certain that pure strains can be established by continuous selection.

4. If we attempt to establish pure strains from patani, kulthi, and pigeon pea, the following colors promise success:

(a) PATANI:—The non-spotted, the spotted with darker,black, and purple areas, the dark purple mottled, and the chocolate-brown and black mottled seeds are the ones to be cultivated separately.

(b) KULTHI:—The non-spotted, and the spotted seeds.

(c) PIGEON PEA:—The drab with chocolate-brown areas, light with chocolate-brown areas, light drab with dark purple areas, light drab, and the yellow-whitish seeds.

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